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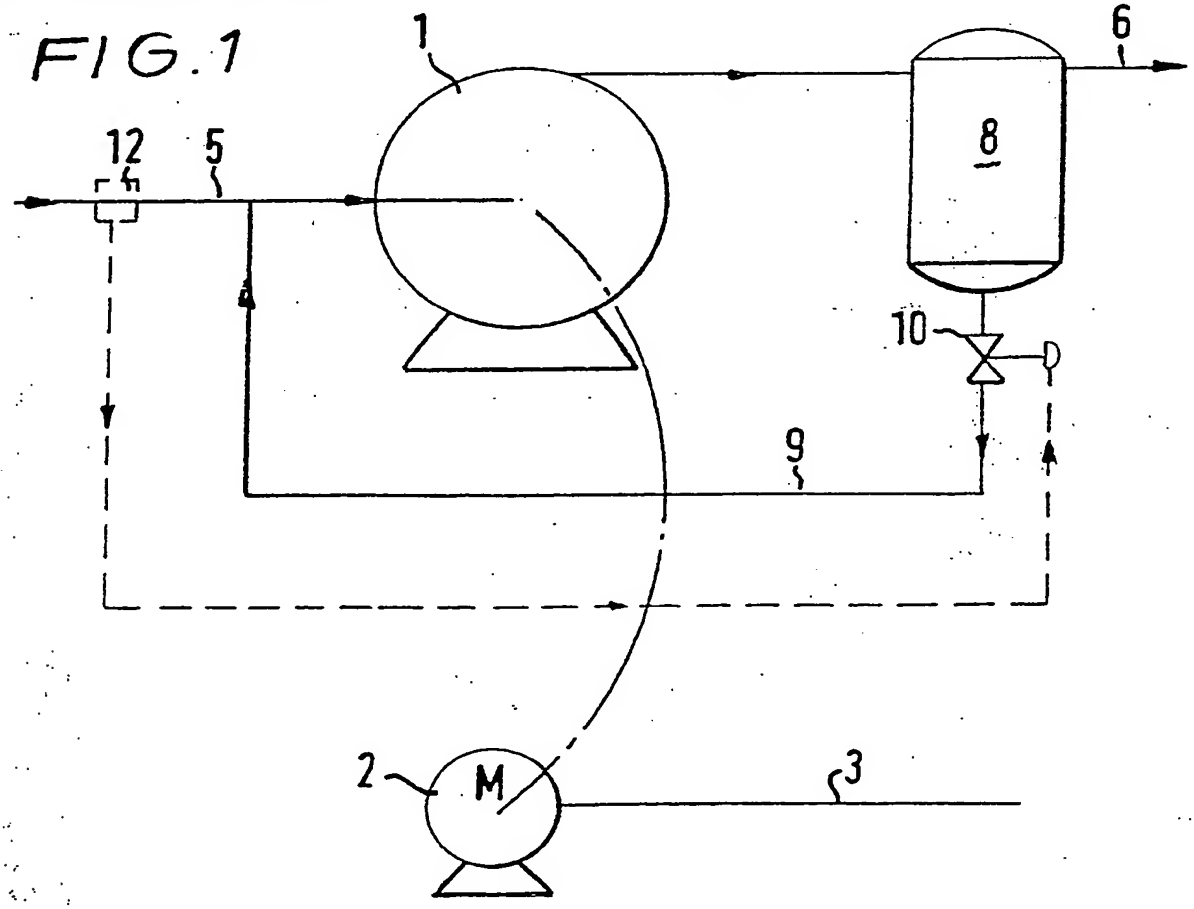
(54) Method and system for controlling the gas-liquid ratio in a pump

(57) The gas-liquid ratio of a multiphase fluid in a pump is controlled by extracting liquid from the fluid stream exhausted by the pump (1) and recirculating through a conduit (9) the extracted liquid back to the pump inlet (5) if the gas content of the pumped fluid exceeds a certain value. Detection means (12) controls a flow regulating device (10) in the conduit (9) and when an unacceptably high gas content is detected device (10) is opened to admit liquid to the inlet (5).

FIG.1



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy

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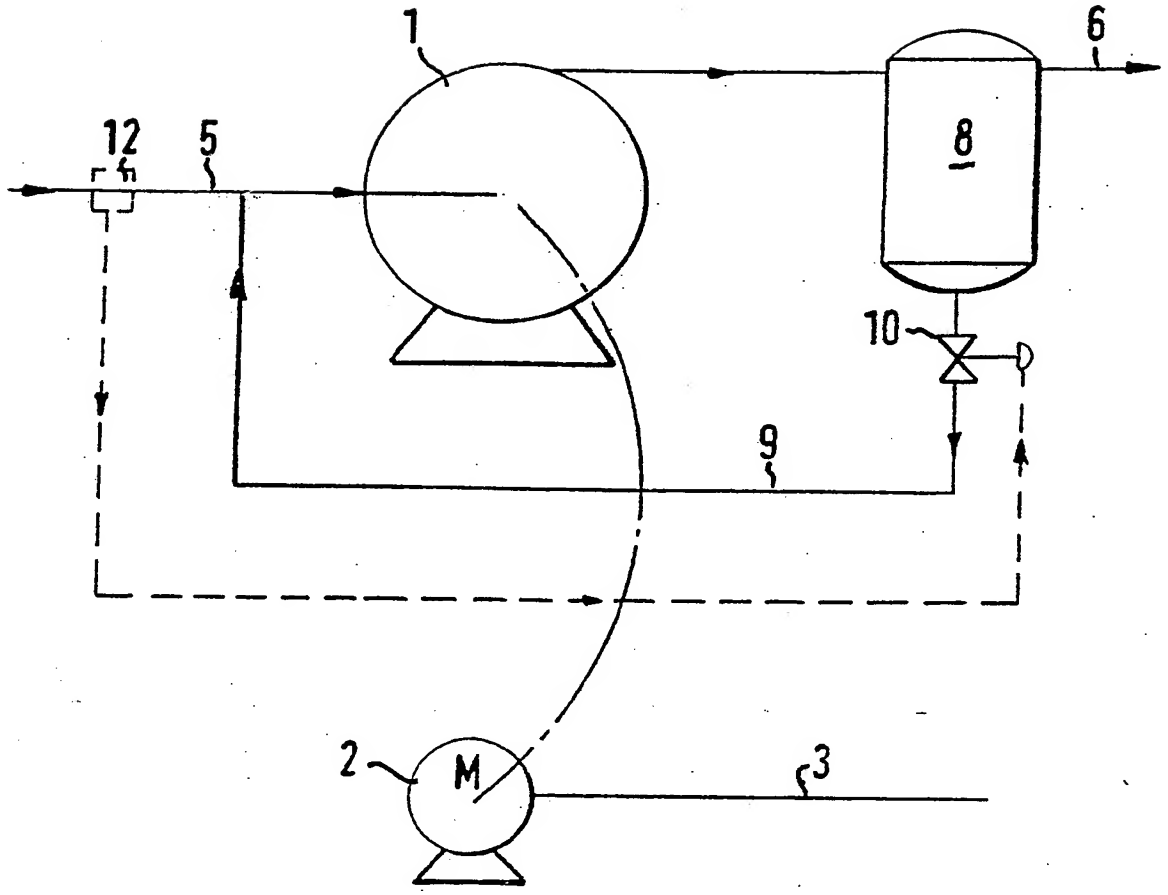
FIG.1



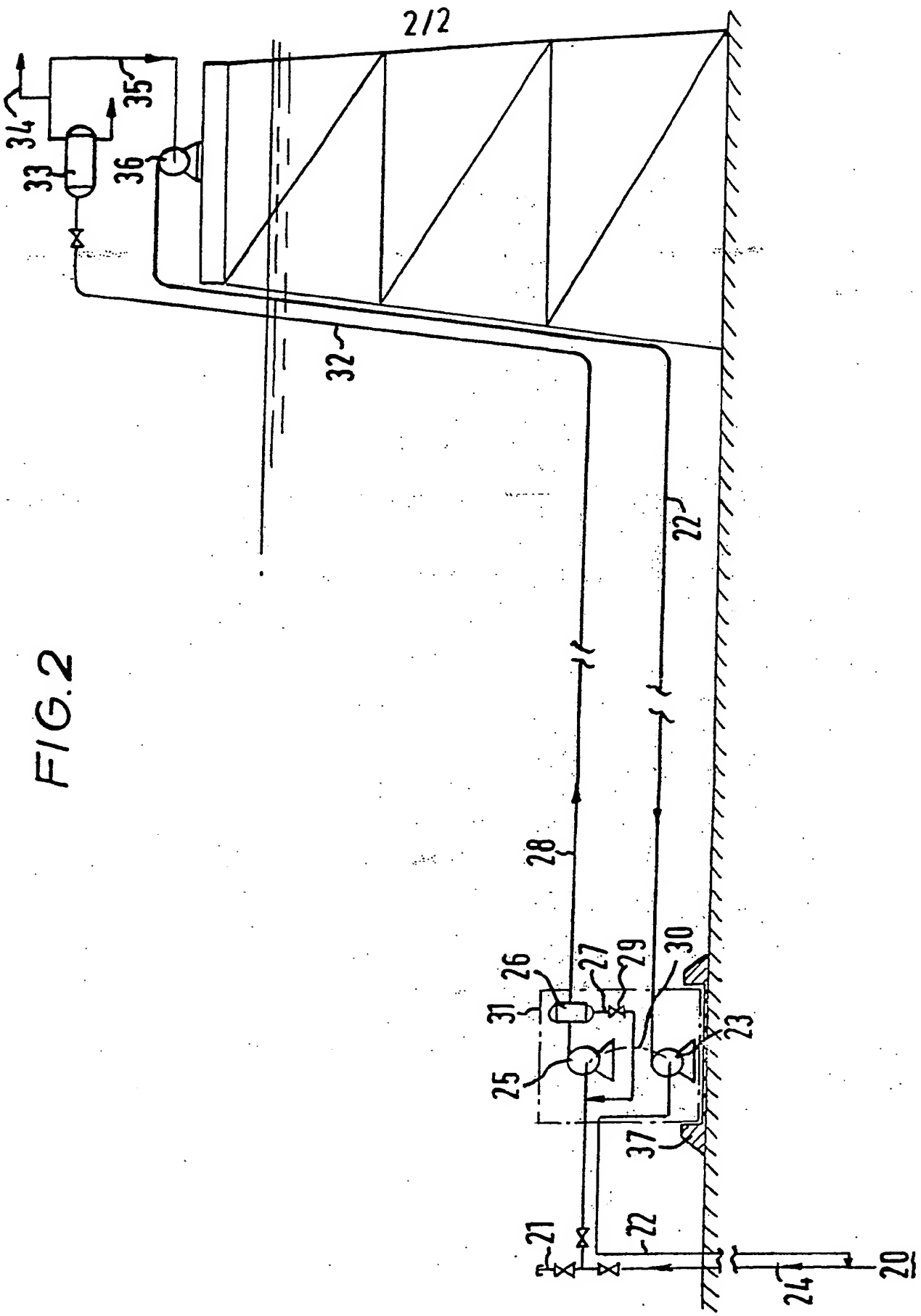


FIG.2

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METHOD AND SYSTEM FOR CONTROLLING THE GAS-LIQUID RATIO IN A PUMP

The invention relates to a method and system for controlling the gas-liquid ratio in a pump for pumping multiphase fluid mixtures.

Boosting the pressure of an unstabilised fluid with a varying liquid and gas content is still a significant problem, in particular during the production of hydrocarbon fluids from an oil and/or gas field. The well effluents of an oil and/or gas production well may contain crude oil, natural gas, condensates, water and some solids like sand and salt. In particular the varying gas-liquid ratio of the effluents, which may suddenly rise from 0% to 100%, make pumping difficult. In general, usage of an oil and gas separation train to facilitate separate monophase pumping of the gaseous and liquid phases is not feasible because it is very costly, in particular for seabed production systems.

Numerous attempts have been made to accomplish pumping of multiphase fluids. For instance, US patent 3,936,214 discloses a centrifugal pump having a rotatable case which impels fluid to one collection point if it is liquid and to another collection point if it is gas whereby the liquid and gas are discharged via separate outlet parts within the pump housing. Drawbacks of the known multiphase pump design are its complex configuration and operation.

Accordingly it is an object of the present invention to provide a method and a system for controlling the gas-liquid ratio in a multiphase pump which do not require a complex design or a complex control system to prevent the occurrence of gas locks in the pump.

The method according to the invention thereto comprises the following steps:

- extracting a selected amount of liquid from a flowline located downstream of the pump,
- detecting the gas content of the fluid mixture at the inlet of said pump, and
- feeding the extracted liquid back to the pump inlet via a feedback conduit if the detected gas content exceeds a predetermined value.

The apparatus according to the invention comprises:

- a liquid extractor connected to a flowline located downstream of the pump,
- means for detecting the gas content of the fluid mixture at the inlet of the pump, and
- a feedback conduit located between said extractor and pump for feeding liquid from the extractor back to the pump inlet if the gas content detected by the detection means exceeds a predetermined value.

The method according to the invention enables extraction of only a selected amount of liquid from the flowline at a location downstream of the pump whilst the remaining liquid and gas of the multiphase fluid stream flows unhampered away through the flowline. The step of extracting liquid from a multiphase fluid provides a major difference between the present method and known fluid recirculation systems for preventing vapour locks at the entry of a pump, such as disclosed in US Patent 4,492,516, since in the known systems no extraction of liquid from a multiphase fluid takes place and there is neither recirculation of liquid in response to an unacceptably high gas content of the pumped fluid.

Another advantage of the system according to the invention is that it allows liquids in the conduit downstream of the extractor to flow back into the pump inlet. This feature is particularly attractive when the pump is fed with pure gas after an insufficient differential pressure.

The invention will now be explained in more detail with reference to the accompanying drawings in which:

- Fig. 1 shows a preferred embodiment of the apparatus according to the invention, and
- Fig. 2 shows the apparatus in a pump station which is powered by well injection gas.

Referring to Fig. 1, there is shown schematically a pump 1 powered by an electrical motor 2. Electrical power is supplied to the motor 2 by an electrical power source (not shown) through an electrical cable 3.

The inlet of the pump 1 is connected to a fluid feed pipe 5 whereas the outlet of the pump is connected to an elongated fluid exhaust flowline 6. A liquid extractor 8 is arranged in the flowline 6 at a location near the pump outlet. The extractor 8 consists of a vessel in which small amounts of liquids are extracted and which is at a location near the bottom thereof connected to a liquid feedback conduit 9. Said feedback conduit 9 is at the other end thereof connected to the fluid feed conduit 5. A flow regulating device 10 consisting of a choke or valve is arranged in the feedback conduit 9 for controlling the flow of fluid through said conduit 9 in response to detection by detector means 12 of an unacceptably high gas content in the fluid feed pipe 5.

During operation of the system a multiphase fluid mixture is pumped by the pump from the fluid feed pipe 5 into the fluid exhaust flowline 6. Some of the liquids exhausted by the pump 1 are extracted from the multiphase flow in the fluid exhaust flowline 6 in the extractor 8. If the detector means 12 detects an unacceptably high gas content in the fluid feed pipe 5 the flow regulating device 10 is opened and liquid flows from the extractor 10 via the feedback conduit 9 to the fluid feed pipe 5 thereby increasing the liquid content of the multiphase fluid at the inlet of the pump 1.

If there are no liquids in the fluids exhausted by the pump 1 which may occur when the upper part of the well tubing is full of gas, for instance during pump start-up, then the exhaust pressure of the pump may be lower in some cases than the pressure in the exhaust line 6 created by the hydrostatic head of the liquid in the flowline 6.

In that case, the fluids in the line 6 will flow back in the extractor 8. Some liquids will then be extracted and fed back to the pump inlet allowing a better pump differential pressure. Once the differential pressure across the pump is sufficient to reach the required pressure in the line 6 to transfer fluids, then the back flow will stop and normal operation will take place. In view of the above it will be understood that the liquid feed back system has the advantage of being self-regulating.

It will be understood that if the volume the liquid extractor 8 is large in comparison to the volume of the fluid recirculation circuit formed by the feedback conduit 9, the pump 1 and adjacent sections of the feed pipe 5 and exhaust flowline 6, a continuous recirculation of liquid via the pump 1 and fluid circulation circuit might take place whilst 100% gas is fed to the feed pipe 5 and 100% gas is exhausted from the extractor 8 into the exhaust flowline 6.

Thus with the aid of a liquid feedback system according to the invention it is possible to pump 100% gas through a flowline using a multiphase pump which can only pump a multiphase fluid containing at least some liquid. It will be understood that the liquid extractor 8 may consist of a vessel which may be coupled either directly to the flowline 6 at a location near the upper end thereof and which may possibly include some storage, as shown in the drawing, or be coupled to the flowline via a T-joint.

It will further be understood that the pump 1 may be any type of pump such as a rotary pump, a turbine or a positive displacement pump. The motor may be any type of motor, such as an electrical motor, an hydraulic motor or a gas-driven turbine.

As illustrated in Fig. 2 the liquid feedback system according to the invention is particularly attractive for pumping of well effluents from a well in which a gas lifting technique is applied to bring the well effluents from the reservoir 20 to the wellhead 21. The injection gas which is injected via an injection line 22 is used to drive a pump motor 23 consisting of a gas-driven turbine. In the well tubing 24 the gas is mixed up with the well

effluents and causes a continuous presence of gas in high quantities in the well effluents passing through the pump 25. To alleviate any problems due to the pumping of a multiphase gas-liquid mixture the pump 25 is equipped with a liquid extractor 26 and liquid feed back loop 27. In use the liquid extractor 26 extracts some liquid from the flowline 28 and if too much gas is detected in the effluents produced from the well a valve 29 is opened in the liquid feed back loop 27 so as to increase the liquid content of the pumped effluents to such a value that an optimum performance of the pump 25 is accomplished. In the embodiment shown the pump 25 and pump motor 23 have a common shaft 30 and they are together with the extractor 26, mounted in a cylindrical housing schematically represented by dash-dot line 31, which is inserted in a cup-shaped base 37 so as to enable easy retrieval thereof for maintenance or repair. The effluents produced via the flowline 28 and riser 32 are separated in a gas-liquid separator tank 33. The separated gas may be split into a gas stream 34 for sale or other purposes and another gas stream 35 which is pumped by a gaslift compressor station 36 into the gas injection line 22. It will be understood that the embodiment shown in Fig. 2 is particularly attractive if a gaslift technique is used in a subsea well at a remote location. In that case the pump motor 23 is driven by the injection gas so that no additional power transfer line is needed to feed the motor. The liquid feed back loop 27 ensures a proper operation of the pump 25 whereas the gas-liquid separator tank 33, and the gas compressor station 36 may be located on an offshore platform or onshore. In this manner a very efficient, cost effective and reliable oil production system is created.

Finally, it will be understood that the liquid feedback system according to the invention is particularly attractive for use in a system for pumping unstabilised well effluents comprising a varying gas content which may occasionally exceed the maximum gas liquid ratio the pump can tolerate.

C L A I M S

1. A method for controlling the gas-liquid ratio in a pump for pumping multiphase fluid mixtures, the method comprising the steps of:
   - extracting a selected amount of liquid from a flowline located downstream of the pump,
   - detecting the gas content of the fluid mixture at the inlet of said pump, and
   - feeding the extracted liquid back to the pump inlet via a feedback conduit if the detected gas content exceeds a predetermined value.

2. The method of claim 1 wherein the pumped fluid mixture consists of well effluents flowing from an oil production well.

3. The method of claim 2, wherein the pump is a rotary pump driven by a motor consisting of a gas turbine which is powered by a gas injected into a well for gas lifting of well effluents.

4. A system for controlling the gas-liquid ratio in a pump for pumping multiphase fluid mixtures, the system comprising:
   - a liquid extractor connected to a flowline located downstream of the pump,
   - means for detecting the gas content of the fluid mixture at the inlet of the pump, and
   - a feedback conduit located between said extractor and pump for feeding liquid from the extractor back to the pump inlet if the gas content detected by the detection means exceeds a predetermined value.

5. The system of claim 4 wherein said gas detection means controls a flow regulating device in the feedback conduit.

6. The system of claim 5 wherein the flow regulating device consists of a valve.

7. The system of claim 5 wherein the flow regulating device consists of a choke.

8. The system of claim 4 wherein the liquid extractor consists of a vessel for storing a selected amount of liquid.

9. The system of claim 8 wherein the feedback conduit is connected to the vessel at a location near the bottom thereof.

10. The system of claim 8 wherein the flowline is connected to the vessel at a location near the top thereof.

11. A method for controlling the gas-liquid ratio in a pump for pumping multiphase fluid mixtures, substantially as described with reference to the accompanying drawing.

12. A system for controlling the gas-liquid ratio in a pump for pumping multiphase fluid mixtures, substantially as described with reference to the accompanying drawing.

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